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Keywords

RFID, Lab, ERP, Design Theory, Validation, Testing

Disciplines

Business Administration, Management, and Operations | E-Commerce | Management Information Systems | Physical Sciences and Mathematics | Technology and Innovation

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An information Systems Design Theory for an RFID University-based Laboratory

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Abstract

RFID technology is defined as a wireless automatic identification and data capture (AIDC) technology and is considered as “the next big thing” in the management and “the next revolution in supply chain”. Recently, the topic has attracted the interest of the industrial community as well as the scientific community. Following this tendency, this paper applies an Information Systems Design Theory (ISDT) for an RFID-based University Laboratory. For practitioners, the paper provides some insights into the set-up and use of RFID laboratory in university settings, and at the same time, it offers a set of hypotheses that can be empirically tested.

1. Introduction

Radio Frequency Identification (RFID) technology has been regarded as one of the “most pervasive computing technologies in history” (Roberts, 2006 p. 18). In the context of management, the technology has been viewed as “the next big thing” (Wyld, 2006 p. 154) and “the next revolution in supply chain” (Srivastava 2004 p. 1), since it allows “any tagged entity to become a mobile, intelligent, communicating component of the organization’s overall information infrastructure” (Curtin et al., 2007 p. 88). However, the concept behind RFID is not new. Indeed, it was used for the first time during the World War II by the British Air Force to differentiate allied aircraft from enemy aircraft.

Though the high potential of RFID technology in terms of operational performance optimisation is obvious, some key questions remain. For example: How should an appropriate business case be constructed? What is the impact on the firm when RFID is

used with only a portion of one's trading partners? Will RFID have similar impacts inside and outside an organization? In the same light, it is worth knowing what considerations are to be taken into account at the industry's level, what factors are conducive to the adoption of RFID by a firm, whether in an interorganizational context or internationally; other issues are to know if traditional IT adoption research paradigms are appropriate, if new performance measurement approaches shall be required to realize value from RFID, how a firm can make efficient use of real-time item/operator entity RFID tag placement, as well as of real-time systems-based decision-making. Moreover, one may ask how RFID and real-time decision-making will change managerial capabilities, who does the tagging, owns the technology, the data, gets the value, pays for readers that benefit to multiple parties, or drives the effort to build standards, etc. (Curtin et al., 2007). Contributing to this debate, many RFID University-based Laboratories are emerging in the world. However, the complexity nature of RFID system turns the set-up of any RFID University-based Laboratory into a very challenging exercise, as it is time consuming, requires an appropriate choice of the various components of the system and support from various actors within RFID industry. The process is even more challenging as there is no theoretical assistance for universities. The objective of this paper is to partially fill this gap by (i) applying an Information Systems Design Theory (ISDT) for RFID University-based Laboratory and (ii) providing validation of our proposals.

Section 2 presents Information Systems Design Theories. In section 3, a literature review on RFID technology and on an RFID University-based Laboratory is presented, followed in section 4 by an Information Systems Design Theories for an RFID University-based Laboratory. Hypothesis testing appears in Section 5 while the conclusion and future research feature in section 6.

2. Information Systems Design Theories

Information System (IS) is defined as "a field of research concerned with the effective design, delivery, use and impact of information technology in organizations and society" (Jones et al., 2003 p. 1). IS is concerned with the design of artefacts and their use in human-machine systems and involves theory and practice to achieve these goals (Martin, 2004; Markus et al., 2002; Gregor, 2002). The goal-oriented perspective of IS has created a rising interest in designing theories within the information system community (Goldkuhl, 2004) as it enables them to draw theory from best practices at operational, management or strategic levels (Martin, 2004).

In general, we can distinguish five types of theory: (i) analytical and descriptive theory, (ii) theory for understanding, (iii) prediction theory, (iv) explanatory and predictive theory, and (v) theory for design and action (Table 1) (Jones et al., 2003; Gregor, 2006).

Table 1: Types of Theory, Source: (Jones et al., 2003; Gregor, 2006)

Type	Question	Example of study
Analyzing and Describing	What is?	Bapna et al., (2004)
Understanding	How? and Why?	Levina and Ross (2003)
Predicting	What will be?	Bapna et al. (2003)
Explaining and Predicting	What? How? Why? and What will be?	Subramani (2004)
Design and Action	How to do something?	Fan et al., (2003)

IS design theory, which is the one used in this paper, is considered part of the theory for design and action (Gregor, 2002; Jones et al., 2003). It is concerned with how to design the artefact (design product) and the design process (method being used to realize the product) (Kourouthanassis, 2006; Walls et al., 2004), which were the components of the IS design theory (Table 2). The design product is composed of (i) the meta-requirements used to deal with a class of problems or goals to which the theory applies (Siponen et al., 2006), (ii) meta-design principles, which describes a class of artefacts hypothesized to meet the meta-requirements, (iii) kernel theories which are relevant theories derived from natural or social sciences governing design requirements, and (iv) testable design product hypotheses, which are used to validate the match between the artefact outcome and the meta-design. The other aspect of an ISDT is the design process and involves: (i) a design method, which describes all procedures used for artifact construction, (ii) kernel theories similar to, or different from, those being used in the design product, and (iii) testable design process hypotheses that can be used to ascertain that the design method results match with the meta-design (Walls et al., 2004; Siponen et al., 2006).

Table 2: Components of an Information System Design Theory, Source: (Walls et al., 2004)

Design Product	
1. Meta-requirements	Describes the class of goals to which the theory applies
2. Meta-design	Describes a class of artifacts hypothesized to meet the meta-requirements
3. Kernel theories	Theories from natural or social sciences governing design requirements
4. Testable design product hypotheses	Used to test whether the meta-design hypotheses meet the meta-requirements
Design Process	
1. Design method	A description of procedure(s) for artifact construction
2. Kernel theories	Theories from natural or social sciences governing design process itself
3. Testable design process hypotheses	Used to verify whether the results of the design hypothesis-based method in an artifact are consistent with the meta-design.

In addition, IS design theory can involve the methodologies, guidelines, principles or tools that are used in the development of the artefacts (Gregor, 2002), in order to accelerate the design process by restricting available options, and thus reducing developers' uncertainty and leading to better development results (Markus et al., 2002). Furthermore, IS design theory allows researchers to generate testable research hypotheses that can be empirically validated using both positivistic and interpretive research methods (Siponen et al., 2006; Markus et al., 2002). More precisely, IS design theory is drawn on three interconnected elements, namely: (i) a set of user's requirements, (ii) a set principles for selecting system features, and (iii) a set of principles deemed effective for guiding the development process. Also, IS design theory is based on a theory, which is also referred to as kernel theory, and provides much more practical implementation methods to practitioners (Gregor, 2002; Markus et al., 2002).

Many researchers have already used the components of an ISDT proposed by (Walls et al., 2004, Table 2) for emerging technologies (Markus et al., 2002; Jones et al., 2003; Kourouthanassis, 2006; Siponen et al., 2006). Our study follows this trend and applies an ISDT for one RFID University-based Laboratory.

3. RFID Technology and RFID University-Based Laboratory

3.1. RFID Technology as Emerging Inter-Organizational Information System

RFID technology is an emerging Inter-Organizational Information System (IOS) that uses radio frequencies to automatically identify individual items or products in real time in a given supply chain (Poirier and McCollum, 2006; Curtin et al., 2007). It does belong to the two main classes of technologies, namely: (i) the Automatic Identification and Data Capture (AIDC) technologies such as bar codes, biometrics and magnetic stripes, and (ii) Wireless technologies such as the local area network and the metropolitan area network (see Fosso Wamba et al., 2008a for more details).

3.2. RFID Technology Components

Any RFID system is a combination of three major technologies: (i) a tag -active, passive or semi-passive- which serves as an electronic database and can be attached to or embedded in a physical object to be identified; (ii) a reader and its antennas which communicate with the tag without requiring a line of sight; and (iii) a host server equipped with a software or middleware that manages the RFID system, filters data and interacts with enterprise applications. The middleware is the backbone of any RFID system. Indeed, it is the place where all business decisions that are used to manage the entire RFID system are configured (Fosso Wamba et al., 2008b).

RFID tag has various sizes and functional characteristics. However, the most important are (i) power source: the active tag contains a tiny battery from which power is drawn, while the passive tag doesn't contain any power source. The semi-passive tag works as a passive tag, but has a power source that enables it to run an onboard sensor (Roberti, 2006a); (ii) operating frequency: the low-frequency tag uses frequencies ranging from 125 to 134 kHz, the high-frequency tag uses the 13.56 MHz frequency, and the ultra-high-frequency tag uses a 866 to 960 MHz frequency. As for the microwave tag, it works with frequencies ranging from 2.4 to 5.8 GHz; (iii) read range: ; (iv) data storage capacity and capability: the RFID tag may either be read only or read/write; the data transmission rates of the active tag is higher than that of the passive tag, and similarly, the data storage capacity of the latter is smaller than that of the former; (v) operational life: owing to its power source, the active tag's operational life is shorter than that of the passive tag (depending on how the power source is being used); (vi) cost: as it lacks a power source, the passive tag is less expensive than the active tag (Asif and Mandviwalla, 2005). In a final analysis, it should be noted that RFID readers (i) may have a read or read/write capability (Ngai et al., 2007), which enables data to be read or read/written on RFID tags through radio frequencies when these tags passed near the reader reading range; (ii) can be configured to control the timing communication with the RFID tag (the reader talks first), or to react to messages from the tags (the tag talks first) (Asif and Mandviwalla, 2005); and (iii) might be a fixed or a mobile device.

3.3. RFID Technology Capability

RFID technology is capable of delivering precise and accurate data from any tagged products (items, cases or palette levels), in real time in a given supply chain, and thus increasing information flow (Riggins and Slaughter, 2006; Datta et al., 2007; Fosso Wamba and Boeck, 2008) and improving supply chain efficiency (Katina and Luke, 2005; Loebbecke, 2007). Moreover, the technology is "expected to revolutionize many of the collaborative supply chain processes and to empower new collaboration scenarios, such as anti-counterfeiting, product recall and reverse logistics, collaborative in-store promotion

management and total inventory management” (Bardaki et al., 2007 p. 1). For example, when adapted to specific context, RFID technology allows a vast range of applications such as inventory management, access control, anti-counterfeiting, logistical tracking, etc.

Despite its high potential, RFID technology is currently facing many problems that prevent its adoption at a large scale. Among these problems, are the issues of standards, the changing RFID middleware options, tags and readers performance (Riggins and Slaughter, 2006), the lack of investment returns (Vijayaraman and Osyk, 2006) and the requirement in terms of (i) strategy redesign, (ii) business process redesign, (iii) IT infrastructure transformation and (iv) organizational structural transformation (Fosso Wamba et al., 2008a). These issues have lead to the establishment of many RFID-based University Laboratories, each of which have to work on a specific area in order to provide some possible answers (Table 3).

Table 3: Some RFID University-based laboratories

University RFID Lab.	Purpose	Source
Auto-ID Labs 1. MIT, 2. University of Cambridge, 3. University of St. Gallen, 4. University of Fudan, 5. Information and Communication University, 6. University of Adelaide and 7. Keio University University of Nebraska-Lincoln	<ul style="list-style-type: none"> • Creating Internet Networks for Things using RFID and Wireless Sensor Networks. • Creating a global system for tracking goods using a single numbering system called the Electronic Product Code • The university has an extensive RFID lab stocked with RFID and material handling equipment that students use for coursework • The Course focused on RFID, RFID in Logistics, and RFID in engineering and business classes. 	Auto-ID Labs ¹ Burnell (2008)
Middlesex Community College in Massachusetts	<ul style="list-style-type: none"> • Certificate program geared toward preparing students to install and service RFID equipment 	Burnell (2008)
Boise State University and the University of Alaska Anchorage Alien's RFID Solutions Center (supported by five universities: Ohio State University, Ohio University Center for Automatic Identification, Wilberforce University, Wright State University and the University of Cincinnati) Oklahoma State University	<ul style="list-style-type: none"> • A joint graduate certificate program in supply chain management with a strong RFID focus. • Developing RFID curricula. • Enhancing RFID studies via student internships at the Solutions Center • Facilitating faculty consulting engagements at the center and other joint projects • Course focusing on RFID system applications in manufacturing and engineering systems. • A systematic statistical approach for experimental design of an RFID system developed. The research has yielded new principles for harnessing information on the complex (nonlinear and stochastic) nature of the process underlying signals from RFID and other sensor networks 	Burnell (2008) Roberti (2006b) Burnell (2008)
Southern Alberta Institute of Technology	<ul style="list-style-type: none"> • To foster innovation and to conduct applied research in Radio Frequency Identification application technologies. • This leading edge facility allows local and national enterprises from all sectors to implement RFID applications in areas such as supply chain management, asset tracking, safety systems and process information analysis 	SAIT (2008)
Texas State Technical College RFID Training Center	<ul style="list-style-type: none"> • Training facility for corporate and student education in RFID. • To provide state-of-the-art workforce training, • To serve as a center of excellence devoted to facilitating the widespread adoption of RFID technologies. 	TSTC Waco (2008)
University of Pittsburgh	<ul style="list-style-type: none"> • Serves as an international resource to academics and members of the business community 	Mickle (2007)

¹ From the Auto-ID Labs web site: <http://autoid.mit.edu/cs/>

ePoly Center at Polytechnic School of Montreal	<ul style="list-style-type: none"> • Training facility for corporate and student education in RFID • Course focused on RFID, RFID in Logistics, and RFID in engineering and business classes • Evaluation of the impacts of RFID/EPC on supply chain management in the context of B2B 	Fosso Wamba et al. (2008a, 2008b) Bendavid et al. (2007)
University of Wisconsin RFID Lab	<ul style="list-style-type: none"> • RFID Project Management • Demonstration and education of RFID technology and applications 	Burnell (2008)
University of Arkansas RFID Research Center	<ul style="list-style-type: none"> • To create and extend knowledge in RFID utilization and its impacts on business and the society 	RFID Research Center (2008)

4. Information Systems Design Theory for an RFID University-based Laboratory

This section deals with ISDT when applied to an RFID University-based Laboratory (Table 2). The various components of ISDT shall be described.

4.1. Meta-Requirements

There are four main categories of meta-requirements: (i) the meta-requirement, which refers to all technology providers, is necessary for the set-up and running of the RFID-based laboratory; (ii) the second one refers to the profile of potentials RFID University-based Laboratory users (e.g. industrial stakeholders, students, policy makers); (iii) the third meta-requirement refers to the RFID University-based Laboratory to support the various RFID applications using different contexts (e.g. manufacturing, retailing, etc.); and (iv) the last meta-requirement is about the ability of researchers working in the laboratory to quickly select RFID technology components and transform “the requirements of potentials users into decision rules to be configured in the RFID middleware”.

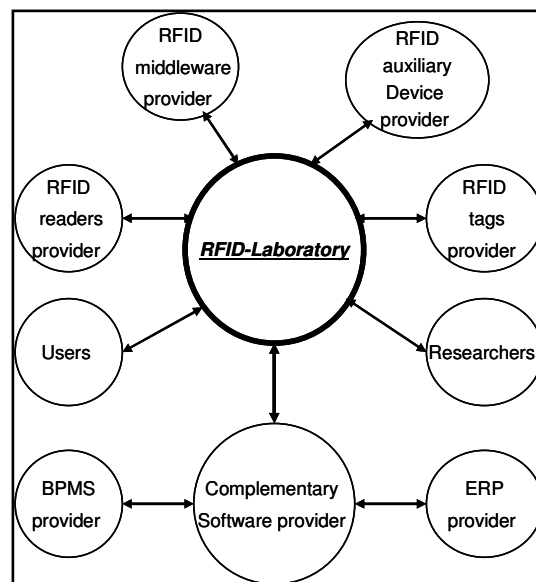
Regarding the set-up and the use of a RFID-based Laboratory, the head of the research centre needs to create a network of all actors ranging from RFID technology providers (tags provider, reader provider, middleware provider and auxiliary RFID system provider -e.g. stack light, motion sensor, etc.-), complementary software providers such as Business Process Management System (BPMS) providers and Enterprise Resource Planning (ERP) providers to potential users (e.g. students, industrial stakeholders).

Indeed, as any RFID system is composed of three major technologies; the head of the RFID-based laboratory needs to establish a strong partnership with the firm involved in the design, testing and distribution of different RFID component. Through this partnership, the research center could act as a bridge between all potential users and all RFID technology providers by putting together all pieces of equipment needed to test a specific application, by enabling potential users to test, learn, and “trial” the technology and allowing the RFID technology providers to refine and adjust their offer to a potential RFID technology adopter. Moreover, the RFID-based Laboratory could facilitate the creation of new partnerships between different RFID technology providers (tag provider with reader’s provider and middleware provider for a specific application), which leads to a “bundle RFID system” offer to potential customers. For example, some applications in the shipping industry may require RFID tags with higher frequencies for longer range, while RFID tags with low frequencies may be needed to access control applications (Asif and Mandviwalla, 2005). Applications at the supply chain level may require passive read/write RFID tag. To cope with the technological needs of potential users,

the diversification issue has to be quickly addressed by the RFID-based laboratory through partnerships.

To be more efficient in this context, the head of a RFID-based laboratory needs to make some choice regarding specialisation. For instance, the University of Cambridge, which is part of the Auto-ID Labs, focuses more on the integration of RFID and other identification technologies into industrial environments by developing specific research themes such as: (i) reduction in the uncertainty of RFID deployment, (ii) methodologies for tracking and tracing objects, (iii) management of product information networks, (iv) quantification of the impact of RFID introduction and (v) RFID integration with sensing and automation systems². On the other hand, the University of Arkansas RFID Research Center is trying to use the laboratory to create and extend knowledge in RFID utilization and its impacts on business and society (Table 3). Specialisation could foster the development of RFID best practices by the industries, sectors and applications, and thus enabling cross-comparisons through collaboration between laboratories.

Figure 1: Potential stakeholders involved in the set-up and use of an RFID University-based Laboratory



4.2. Meta-Design

Researchers working in an RFID-based laboratory could be regarded as the designers or the integrators of the product artefact (RFID system). Indeed, they need to have the required knowledge to analyse user's needs, identify the required RFID system, install the system, test it and translate "users' business requirements" into decisions rules in the middleware. The key issue here is the designers' capacity to design a product artefact that is flexible enough to meet the various users' needs. For example, by using a motion sensor, designers could use the same gate equipped with RFID reader to simulate a "receiving process" (inbound) or a "shipping process" (outbound) depending on the direction of the movement. Also, they could use BPMS to model and simulate different configurations of the RFID system in order to choose the optimal one. This may help accelerate and enhance the accuracy of the components selection as well as the RFID system integration process. To achieve this, they need to rely on some basic communication quality so as to create fruitful exchanges with all RFID-based laboratory stakeholders.

² From Cambridge Auto-ID Lab web site: <http://www.autoidlabs.org.uk/>

4.3. Kernel Theories

Given the emerging nature of RFID technology, the wish of stakeholders involved in the project to better understand the technology and assess its impact on their business processes, three theories that may apply to this ISDT have been identified, namely: (i) Business Process Reengineering (BPR), (ii) IT business value and impacts, and (iii) IT diffusion theory.

Firms have been facing strong challenges such as market globalization, aggressive competition, increasing cost pressures, the rise of customized demands with high product variance, the management of the short shelf-life of grocery goods, and strict traceability requirements. In order to cope with all this, firms have been investing huge amount of money on information technology. However, these investments do not always lead to improved organizational performance. This phenomenon is better known as the “IT productivity paradox” (Brynjolfsson and Hitt, 1996) and is due to the macroeconomic approach that is being used to assess the impact of IT investments (Oz, 2005). Many authors call to the use of an alternative approach known as the process-oriented approach, which puts emphasis on the evaluation of IT investments at the locus of the impact: “business process” (Zhu and Kraemer, 2002).

“A business process is a set of interrelated activities which have definable inputs and, when executed, result in an output that adds value from a customer’s perspective” (Al-Mudimigh, 2007 p. 869). BPR or Business Process Management (BPM) draws on business process and aims at improving organizational performance in terms of cost, quality, service, and speed (Hammer and Champy, 1993; Ulbrich, 2006). BPR is considered a key dimension in IT implementation (e.g. ERP, integrated standard software packages and enterprise application systems). Actually, in order to grasp the real potential of an emerging IT, the current intra- and inter-organizational business process needs to be redesigned prior to any implementation (Al-Mudimigh, 2007). In the same light, Sarker and Lee (2002) states that “IT is the central object of redesign in the redesign process” (p. 10). Also, the transformational effects of IT investments need to be explored by taking into consideration the firm IT strategy, IT management capability and external environment and industry factors (Gregor et al. 2006). IT diffusion theory offers important insights into the way in which, and the speed at which, an emerging technology is adopted by the members of a social system (Rogers, 2003; Venkatesh et al., 2003): by considering IT characteristics (e.g. complexity, compatibility and relative advantage), organizations’ characteristics and the factors that influence the adoption (e.g. mandates, centralization, organizational slack), diffusion process and contextual factors (e.g. level of competitiveness, reputation, R&D allocation, technology standardization) (Fichman, 1992; Damanpour and Schneider, 2006).

4.4. Design Method

Many recent studies on RFID technology suggest that it is not a “plug and play technology” (Fosso Wamba et al., 2008b). To grasp its impacts on firm performance, the integrator needs to focus on (i) the product value chain of the firm, (ii) critical activities within that product value chain and (iii) core business processes associated to these activities. Based on these prerequisites, the first design method should focus on the intensive use of a BPMS in order to propose various business processes scenarios integrating RFID technology. This may help RFID laboratory integrators to easily transform firm business requirements into “virtual” RFID laboratory component selection, thus reducing the cost associated to the simulation of each application in the laboratory. The second design method focus implies that integrators need to design the RFID laboratory as flexible as possible in order to handle various core business processes from various industries.

4.5. Testable Design Product and Design Process Hypotheses

Based on the proposed kernel theories of this ISDT, the following hypotheses have been formulated:

1. The RFID University-based Laboratory offers a vendor independent environment for the testing and validation of various scenarios integrating RFID technology (H1).
2. The RFID University-based Laboratory is a viable means to evaluate the impact of RFID technology on supply chain process performance (H2).
3. The RFID University-based Laboratory contributes to accelerate the adoption decision of RFID technology among potentials adopters (H3).
4. The RFID University-based Laboratory acts as an enabler of knowledge transfer among potentials users or adopters (H4).
5. The RFID University-based Laboratory contributes to assess the user perception of RFID technology complexity (H5).

All these hypotheses can be empirically tested using both positivistic and interpretive research methods (Siponen et al., 2006; Markus et al., 2002).

5. Validation

Our hypotheses have been tested in one RFID University-based Laboratory (Figure 2). The laboratory use components from various suppliers (Table 4).

On the left side of Figure 2, we have an RFID portal including:

- Photo eye (1) for automatic product detection and trigger to activate two fixed antennas (2), allowing the antennas to be awakened and transmits radio waves to a fixed reader (3) only where necessary. The reader captures or updates the information written on the tags (4).
- A stack light (5) linked to the fixed reader allows the confirmation of the status of the readings as the products (or boxes) are passing on the conveyor belts (6).
- On the right side of figure 2 of an RFID portal (7) with four two fixed antennas, two photo eyes and one fixed reader similar to those on the left side of figure 2.
- The third part of the laboratory is composed of: an ERP server provided by SAP (8 d), two middleware's servers where all the business rules are configured (8 a, b) and one PBMS server from IDS Scheer AG (8 c).

In the context of supply chain applications, the RFID portal on the left side of figure 2 could be used as the supplier's shipping dock and the RFID portal right side of figure 2 as the retailer receiving dock.

- Also, there are the three screens on the walls (9) provided by the research centre, where all the information resulting from transactions is projected, allowing participants to follow the information flow in real time, as each transaction is automatically performed.

This laboratory has been used for teaching purposes and for supply chain redesign integrating RFID technology in the retailing and utility industries, thus demonstrating its high flexibility and adaptability (H4).

Regarding teaching, the laboratory was used for courses at the undergraduate and postgraduate levels. The use of the laboratory at the two levels involved the tagging of various products with different characteristics (ex. Bottle with water, oil or cream, product with metal, etc.), the testing of reader's reliability based on the type of product and the orientation of antennas, and the analysis of data capture by the reader in the middleware. Moreover, students at postgraduate levels were involved in the data collection process and

their validation. They were also implicated in the mapping of existing business processes, the mapping of various scenarios integrating RFID technology using the BPMS tool. This exercise helps to validate the feasibility of redesign business processes integrating RFID technology, assess their business value at different level of the supply chain and their technological feasibility through iterative discussion with key industrial and technological respondents. Finally, students at postgraduate levels were involved in the demonstration of the integration of information systems (ERP and middleware) and optimization of business processes in the laboratory. This step demonstrates that the implementation of RFID in the supply chain seems possible in terms of business and according to a technological perspective (H2).

Almost one-third of the students who undertook Master's degree programs dealing with RFID technology have chosen to carry out their final projects on this topic. In addition, four of these students have decided to continue their doctoral studies on RFID technology, which highlights the importance of an RFID-based laboratory as a powerful teaching tool.

The laboratory has enabled the actors involved in different supply chains under study to identify opportunities for the optimization of this technology. At the same time, it raised (i) the complementary investment that is needed to achieve the potential of RFID technology (ex. IT and warehouse infrastructures upgrading, employee training and change in management); and (ii) the limits of this technology in their specific context (ex. Standards, IT integration, security) (H5). After studies were being conducted in the laboratory, the actors involved in the retail supply chain have decided to conduct a pilot study in their settings (H3); but those of the utility industry were reluctant to move forward with a pilot study in their field. Indeed, the integration of the RFID-based infrastructure in the utility environment calls for a major redesign of their current IT infrastructure, and the adoption of a "new IT layer" from a vendor different to their current traditional IT vendor. One of the managers involved in the project said: *"we are going to wait for the RFID package from our current IT vendor, so we'll not have to add a new IT layer into our infrastructure, and thus avoid the problems of integration, interoperability and security"* (H1). Finally, the results of these studies were presented during numerous conferences, published in leading journals or integrated in book chapters (H4).

Figure 2: ePoly RFID Laboratory

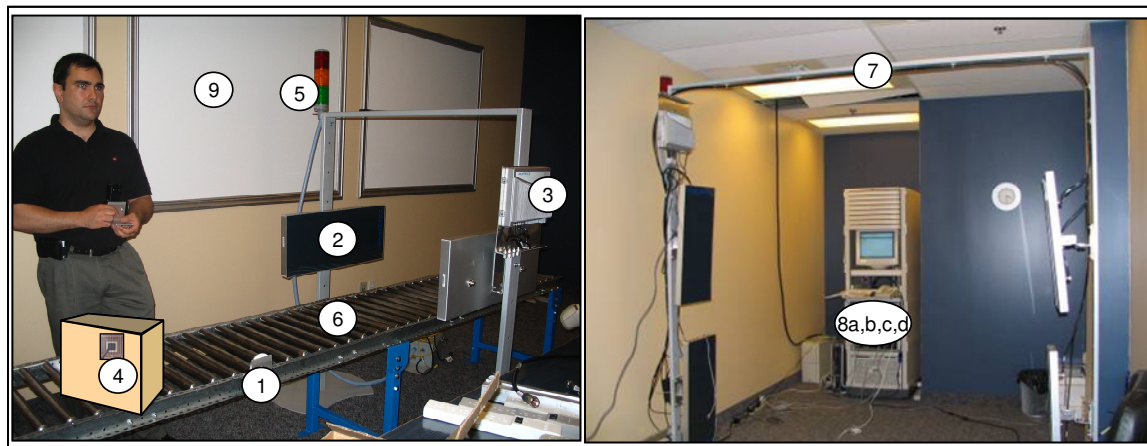
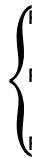
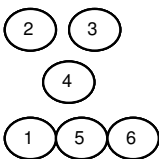
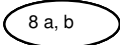
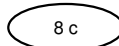
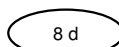


Table 4: Major suppliers of the ePoly RFID Laboratory equipments

Actor	RFID-Laboratory components	Number
Hewlett-Packard (HP)	 RFID reader - antennas provider: RFID tags provider: RFID auxiliary device provider:	
HP, Shipcom Wireless, Ship2Save	RFID middleware provider:	
IDS Scheer AG	PBMS provider:	
SAP	ERP provider:	

6. Conclusion

In this paper, an ISDT that is fit for the design, implementation and use of one RFID University-based Laboratory is being used. The said laboratory has been used for academic (teaching and research) and industrial (RFID applications testing and validation) purposes. The study offers some insights into the set-up and use of RFID-based laboratory in university settings and proposes a number of empirically testable hypotheses that are likely to be useful to researchers. The next logical step of this research work could be the validation of our hypotheses using empirical data of pilot studies conducted by all firms involved in this study. Finally, in the context of supply chain, RFID technology can also be considered as an “open innovation”. Indeed, to fully grasp the real value of RFID technology, we saw that members of the supply chain should establish co-development partnerships with various players in the RFID industry. In fact, co-development partnerships are viewed as “increasingly effective means of innovating the business model to improve innovation effectiveness” (Chesbrough and Schwartz, 2007 p. 1).

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